Title of Project: Electronic Exchange of Poisoning Information

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STRUCTURED ABSTRACT

Purpose: The purpose of this study was to develop, implement, and evaluate a replicable, scalable infrastructure (processes and informatics tools) for health information exchange (HIE) supported ED–PCC collaboration.

Scope: Poison control centers (PCCs) and emergency departments (EDs) collaborate to provide care for poisonings and poison exposures, but do not share information systems. Health information exchange supported collaboration could reduce error, improve decision-making, and improve continuity of care for poisonings.

Methods: We engaged stakeholders, users, and experts throughout the study in planning and design. With clinician guidance, we created a purpose-designed Health Level Seven (HL7) Consolidated Clinical Document Architecture (C-CDA) Standard template for use by PCCs in sending case information to EDs, along with a mapping of PCC data to the template. We developed software called SNOWHITE that implements the mapping and enables PCC participation in standards-based health information exchange. We accomplished and enhanced design, development, and implementation through software prototyping, usability assessments, workflow re-design, system dynamics modeling, and other approaches.

Results: We achieved standards-based health information exchange by a U.S. PCC, including bi-directional HL7 C-CDA document exchange with an external health care organization, and integrated health information exchange into routine PCC operations and workflow for 2.5 years. We developed tools and approaches that are replicable in other PCC settings. We completed technical work and pre-implementation testing for ED workflow integration of bidirectional ED-PCC health information exchange.

Key Words: Health Information Exchange, Poison Control Centers, Workflow, Health Information Interoperability, Patient Care

PURPOSE

The purpose of this study was to develop, implement, and evaluate a replicable, scalable infrastructure (processes and informatics tools) for health information exchange (HIE) supported ED–PCC collaboration. The specific aims were as follows:

Aim 1. Develop a model process for HIE supported ED–PCC collaboration. Using a user-centered design approach, we developed a replicable, scalable model process for HIE supported collaboration. [1] We planned to engage a key standards organization, Health Level Seven International (HL7) to ensure broad relevance.

Aim 2. Develop and implement informatics tools for HIE supported ED–PCC collaboration. Using a user-centered design approach, we will develop informatics tools to facilitate the process of HIE supported ED–PCC collaboration, including: defining techniques for establishment of an HIE connection for a patient, identification and implementation of standard document templates and terminologies, and development of tools for workflow integration such as a web-based dashboard for the PCC and the addition of notification functionality to existing emergency department information systems.

Aim 3. Evaluate the effects of the model HIE process and informatics tools on workflow, communication, efficiency, and utilization. We will conduct a basic evaluation of the HIE supported collaboration process. We will determine user perspective through interviews and surveys, and will determine the effect on care delivery with objective measures of efficiency and utilization.

SCOPE

Background

Poison control centers (PCCs) and emergency departments (EDs) collaborate to provide care for poisonings and poison exposures, but do not share information systems. PCCs collaborate daily with emergency departments to provide care for patients. U.S. PCCs consulted on 656,235 cases of unintentional poisoning managed in healthcare facilities in 2017, and the Centers for Disease Control & Prevention reported 70,237 drug overdose deaths. [2] [3] In many of the cases, the PCC refers the poisoned patient to the ED. If instead the poisoned patient goes directly to the ED, the healthcare facility often contacts the PCC for consultation. In cases where the PCC refers the patient to the ED, the poison center specialist contacts the ED and provides information about the poison exposure to a nurse, mid-level provider, or physician. In either case, the specialist provides clinical toxicology consultation to the healthcare professional that includes information about the toxin, expected clinical effects, monitoring parameters, and specific treatment. The PCC and ED share information about the patient, the patient's status, and circumstances surrounding the poison exposure throughout the ED visit. *As situations evolve, the PCC and ED are in regular communication, and both parties assess and reassess the situation as new information becomes available. The ED care providers verbally share clinical information with the PCC, including patient symptoms, general condition, and the results of certain laboratory tests; the PCC frequently updates treatment recommendations as additional information becomes available.* Multiple handoffs can occur for both the PCC and ED. Information may be communicated to one or multiple ED care providers depending on the workload in the ED and the status of the poisoned patient or other patients in the ED, but never at the same time. The subset of patient information documented during this complex process remains isolated within the respective information systems of the ED and PCC.

Verbal information exchange between PCCs and EDs can lead to miscommunication, data loss, and error. Currently, electronic data and information collected by PCCs are not electronically exchanged with other patient care settings in order to facilitate care of an individual patient. PCC specialists and ED care providers communicate select data and information to each other via telephone and infrequently, facsimile. This approach leaves ample opportunity for miscommunication, inadequate communication, and error. In preliminary studies, we identified safety vulnerabilities in this process. [4] Examples of safety vulnerabilities include: difficulty establishing synchronous verbal communication via telephone, discussion of multiple patients during the same telephone conversation, and communication with non-clinical staff members. Reliance upon verbal communication can lead to loss of data and medical errors. ED care providers are particularly prone to errors related to verbal communication because they carry a very high communication load, characterized by frequent interruption. [5, 6] [7] This vulnerability is magnified by high patient volume, and EDs are increasingly subject to a crisis of overcrowding.[8, 9] Both ED care providers and PCC specialists in poison information experience multi-tasking, shift changes, and interruptions. These circumstances complicate workflow and create additional opportunities for error.[10]

Context

Health information exchange supported collaboration could reduce error, improve decision-making, and improve continuity of care for poisonings. This study sought to establish a replicable, scalable process for HIE supported ED–PCC collaboration, along with a local demonstration project. This is an *essential first step toward widespread ED–PCC health information exchange* to support continuity of care. The study also sought to produce open source software and tools to facilitate adoption by other EDs and PCCs. Availability of these tools will lower the barriers to adoption for EDs and PCCs.

METHODS

Aim 1. Develop a model process for HIE supported ED–PCC collaboration. Using a user-centered design approach, we developed a replicable, scalable model process for HIE supported collaboration. [(1)] We planned to engage a key standards organization, Health Level Seven International (HL7) to ensure broad relevance.

Stakeholder Meetings and Consultation for Process Design. In order to develop a model process for ED-PCC health information exchange, we conducted a series of monthly planning meetings including stakeholders from the Utah PCC, Intermountain Healthcare (IHC), and the Utah Health Information Network (UHIN) during the first year. During these meetings, we defined a reference model and the set of core HIE actions necessary to support the process we envisioned. We discussed and determined the technologies and resources that would or could be used to enable these core actions. We retained the guidance of a consultant, Dr. Shaun Grannis, during this planning process. Key artifacts supported the planning process: a set of use cases authored by Drs. Cummins and Crouch, previously completed workflow and information requirements analyses, and an initial process design drafted by Dr. Cummins and the study team.

Technical Meetings for Process Design. Technical meetings followed the planning meetings, and took place approximately every two weeks for the remainder of the grant. Organized by Dr. Cummins and the study team at UU, these meetings brought together technical personnel from UU, IHC and UHIN to facilitate technical development, communicate about progress and barriers, and make decisions. Clinical personnel frequently joined these meetings to participate in decision making and planning whenever the team needed clinical input or was considering changes that would alter the process of information sharing and communication.

HL7 C-CDA Document Analysis. One of our first challenges was to identify which of the nine available HL7 Consolidated Clinical Document Architecture (C-CDA) document types that could be used to support the necessary HIE actions, considering the type of information that would need to be transferred with each action. Each HL7 C-CDA document is composed of a header and a body. The body of each HL7 C-CDA is composed of a set of required and optional fields that contain clinical data. In prior work, we had described the types of information shared during telephone calls between a poison center and its collaborating emergency departments. Here, we mapped those information types to specific sections contained in a set of candidate HL7 C-CDA document types. Then, we determined which

document types best matched the information requirements for our use case. We conducted two independent mappings, with disagreement resolved by a third analyst with domain expertise in poison control. [11]

System Dynamics Modeling to Simulate PCC Workflow. One of the major concerns for both ED and PCC stakeholders is the impact on workflow. To describe and estimate the effect of the new process of PCC operations, we conducted a system dynamics analysis to understand the underlying factors that drive the current PCC workflow and better anticipate ways in which PCC operations may be affected. Data sources included relevant literature, five 1:1 interviews with team members knowledgeable about the current and proposed processes, and one direct observation session at the Utah PCC. Using the information gathered from these sources, we created three system dynamic models that visually depict and simulate the PCC workflow. The first qualitative model described pre-HIE operations and the second qualitative model described post-HIE integration operations. The quantitative model simulated post-HIE integration operations in terms of case flow through the PCC. We validated model structure during two group sessions. [12]

Analysis of Coded Chief Complaints and Other Potential Triggers. We conducted an analysis of coded chief complaints corresponding to poisoning related diagnostic codes in two years' of de-identified Intermountain Healthcare emergency department encounters. The purpose of the analysis was to determine chief complaints with high positive predictive value for poison exposure. We used domain experts to identify coded chief complaints that would be highly likely to be associated with poison exposure. Then, we described the diagnostic codes associated with those high PPV chief complaints. We also worked with toxicology domain experts to determine other electronic health record data that could be used to automatically identify poison exposure cases and initiate or "trigger" the process of HIE, such as abnormal diagnostic testing results or the administration of antidotes such as naloxone.

Workflow Changes to Support Patient Identity Matching. To strengthen the collection of identifiers that support patient identity matching, we (1) changed documentation practices to support complete and consistent documentation of patient identifiers used in automated patient identity matching, and (2) implemented staff training to improve collection of identifiers. We conducted large group training sessions, superuser training, and engaged in one-on-one coaching of staff. We created and provided a written user guide. We also displayed reminders on wall-mounted screens located at the PCC. [13]

Legal Aspects of PCC Communication and Information Sharing. In collaboration with the University of Utah Center for Law and Biomedical Sciences, we conducted a review to definitively describe the legal and regulatory context for health information exchange and other innovations in communication and information sharing. [14]

Aim 2. Develop and implement informatics tools for HIE supported ED–PCC collaboration. Using a user-centered design approach, we developed informatics tools to facilitate the process of HIE supported ED–PCC collaboration, including: defining techniques for establishment of an HIE connection for a patient, identification and implementation of standard document templates and terminologies, and development of tools for workflow integration such as a web-based dashboard for the PCC and the addition of notification functionality to existing emergency department information systems.

HL7 C-CDA Consultation Note Template Development. We worked iteratively with a team of emergency department end-users to determine an optimal format for presenting PCC case information. During the meetings, we used a whiteboard and dry erase markers to iteratively represent and refine their preferences. Then, we used formatting within HL7 C-CDA required and optional sections, to structure and present information to meet their preferences as closely as possible. We created mockups of sample HL-7 C-CDAs using a prototyping tool and validated these with the end-users. Then, we created the XML template for poison center use, using HTML formatting within sections. [15]

Mapping of Poison Center Data to HL7 C-CDA Consultation Note. We mapped coded and free text data from the Utah PCC database, an instance of toxiCall®, to the HL7 C-CDA schema and the XML template using Altova MapForce® version 2016, with extensive use of custom data transformations. [15] In 2018, we revised the mapping to address changes in the Utah PCC database, following a new release of toxiCall®.

Software prototyping. We created low-fidelity sketches of designs on paper with iterative refinement in collaboration with users. Next, we designed an interactive high-fidelity prototype through wireframing. We used think-aloud and measurements with the System Usability Scale (SUS) to iteratively assess usability. [16, 17]

Sociotechnical core design sessions. As our software engineers began to build SNOWHITE, it became apparent that we needed to re-design the user interface to accommodate the most recent technical and process decisions. We engaged the socio-technical core of the University of Utah Department of Biomedical Informatics and faculty members Dr. Charlene Weir and Dr. Frank Drews to assist us with the re-design. Following a baseline heuristic usability assessment, we held two design meetings, during which we used printouts of displays, along with some rudimentary cutting and pasting, to iteratively refine the design of the user interface. We developed SNOWHITE 1.0 based upon the second design. [18]

Development of Versions 1.0 and 2.0. We created a de-identified version of the Utah PCC database to support development efforts. Software engineers working with our research team created the application using Java and AngularJS, implementing the HL7 C-CDA data mapping with Java code we produced using Altova Mapforce. We developed the application with iterative input, engagement, and testing from end-users at Utah PCC and the research team, every 1-2 weeks. [18]

Utah PCC Implementation. The first step in Utah PCC implementation was deployment of workflow modifications necessary to support the use of SNOWHITE and the health information exchange process at the Utah PCC, and in particular, routine use of the free text template that staff used

in documenting cases. We conducted software testing, end-to-end transmission testing and formative software usability testing. Upon completion of testing, we conducted group and individual user training on the SNOWHITE software (early 2017), and we began live health information exchange with two super-users. These super-users sent HL7 C-CDA consultation notes using SNOWHITE 1.0 for every poison center case referred to an emergency department, or initiated by an emergency department. We worked closely with the super-users to identify issues and opportunities for improving SNOWHITE 1.0, and for pairing workflow with use of SNOWHITE. We met frequently as a team to review issues and requests from the super-users and plan a subsequent version, SNOWHITE 1.1. In order to maximize user acceptance of the software, we delayed center-wide implementation of SNOWHITE until the release of version 1.1.

IHC ED implementation. Of necessity, we altered our original implementation plan in response to Intermountain Healthcare's fall 2013 decision to adopt and implement Cerner throughout the health care organization, and changes to the IHC administrative structure that affected the teams with which we were collaborating. Upon implementation and stabilization of iCentra at two study sites in year three, we were able to assess the new ED tracking system interface and workflow, and began to plan an approach to ED side workflow integration on the basis of ethnographic observation, through regular planning meetings with IHC technical and clinical collaborators. We subsequently progressed to testing and technical implementation.

Aim 3. Evaluate the effects of the model HIE process and informatics tools on workflow, communication, efficiency, and utilization. We will conduct a basic evaluation of the HIE supported collaboration process. We will determine user perspective through interviews and surveys, and will determine the effect on care delivery with objective measures of efficiency and utilization.

Evaluation of Software and Tools. In order to evaluate SNOWHITE and its artifacts, we conducted semi-structured interviews divided into 3 parts: 1) General questions about their experience using the ED-PCC collaboration software, including how much they use it and for how long, has it improved their workflow, has it created any increased risk of error; etc. and 2) A set of questions about the usability and usefulness of 3 HL7 C-CDA documents from Intermountain (referral, progress notes, and discharge summary). The focus was on the sufficiency of the content for understanding the patient's situation, the ease of reading the document, and the process by which it might fit into overall workflow; and demographic questions. The University of Utah Department of Biomedical Informatics Socio-Technical core conducted the interviews. Members of the research team who have previously interacted with Utah PCC staff did not conduct interviews, an approach intended to minimize bias. The interviews took place in November 2019.

RESULTS

We present our results in three sections: (1) results and discussion organized by aim, followed by (2) conclusions, and (3) significance and implications.

Aim 1. Develop a model process for HIE supported ED–PCC collaboration. Using a user-centered design approach, we developed a replicable, scalable model process for HIE supported collaboration. [1] We planned to engage a key standards organization, Health Level Seven International (HL7) to ensure broad relevance.

Overall Process Design. We successfully designed (and implemented, as described subsequently) a health information exchange architecture based upon the HL7 C-CDA standard to enable ED-PCC health information exchange, now used operationally by the Utah PCC and its partners (see figure 1).

Analysis of Coded Chief Complaints and Other Potential Triggers. Through analysis of coded chief complaints, we identified a set of codes that are highly specific tor poison exposure and could be used as "triggers" in IHC's EHR that automatically initiate consultation with a PCC. However, as configuration and implementation of IHC's new iCentra system progressed, we learned that the new system would not implement IHC's set of coded chief complaints and so the coded chief complaints that we analyzed could not be used as triggers. Additionally, we were unable to obtain definitive information about plans to modify iCentra to implement any particular set of chief complaint codes vs. free text. Given this circumstance and the need to define triggers, we changed direction. We worked with clinical toxicology domain experts to identify highly specific triggers based upon the results of laboratory/ diagnostic testing (for example, abnormal toxicology screening test results), and some treatments.

Workflow Changes to Support Patient Identity Matching. Compared with the same time period in 2016, we found a 27% increase ($p < 0.001$) in Utah PCC collection of date of birth for cases referred to a health care facility. Improvements in the collection of other identifiers ranged from 0 to 8%. Additionally, we found that successful automated identity matching by UHIN increased from 7 to 77% (100 of 130) of the HL7 C-CDAs in 2017 compared to 2016. The remainder of the HL7 C-CDAs resulted in either no match or multiple possible matches. UHIN forwarded all HL7 C-CDAs to the destination health care organization, as specified by Utah PCC personnel within the HL7 C-CDA. However, storage in the clinical health information exchange (cHIE) was limited to HL7 C-CDAs that matched to the UHIN master patient index (MPI). In summary, simple workflow changes resulted in dramatic improvement to automated patient identity matching for PCC cases. Date of birth, not routinely collected by U.S. PCCs, is critical for linking PCC patient records for health information exchange. [13, 19]

Pre-Implementation Ethnographic Observation (ED). Through ethnographic observation, we found that clinicians have access to pre-arrival information on patients, but rarely read the notes, indicating that they do not typically find helpful information by doing so. We observed a pattern by which clinicians order consultations by specialists, and the organization of certain consultations and labs under the category "toxicology". We also observed notification functions that alert clinicians when consultation are complete, and allow them to readily open and read consultations. These observations

regarding ED workflow and ED tracking system served as the basis for updating our approach to ED side workflow integration.

System Dynamics Modeling. The first qualitative model of current operations included 17 factors characterizing pathways that relate to time spent by specialists in poison information (SPIs) on the phone. The second qualitative model, describing operations post-HIE integration, included 19 factors. As would be expected, many pathways that led to increases in calls from hospitals and outgoing calls from the PCC transitioned to pathways that lead to increases in SPI time on the computer in the second model. Finally, the quantitative model that we used for simulation included 20 factors, including two switches labeled "ED to PCC communication" and "PCC to ED communication." During simulation of the ED-PCC HIE integration, we found that overall communication workflow is minimally impacted, given only 15% of PCC cases are ED cases. Increasing the percentage of ED cases resulted in more drastic changes in the model and more substantial impacts on PCC workflow. This analysis yielded important insights as we worked with Utah PCC staff concerned about impacts on workflow. [12]

Legal Aspects of PCC Health Information Exchange. The review established the legal framework under HIPAA by which PCCs may exchange information electronically for treatment without patient authorization. However, other emerging forms of communications, such as text (SMS) messaging and instant messaging are problematic and must be handled carefully as PCCs may not inadvertently reveal PHI through these forms of communication. As PCCs gain access to external patient data, SAMHSA may limit their ability to access records of treatment provided under federally funded substance abuse treatment programs, information which may prove highly relevant to treatment in the case of drug overdose. It was important to develop and publish this review, alongside the process and tools for PCCs to participate in health information exchange, as many centers have questions about the legality of their engagement in HIE and its regulatory considerations. [14]

Aim 2. Develop and implement informatics tools for HIE supported ED–PCC collaboration. Using a user-centered design approach, we developed informatics tools to facilitate the process of HIE supported ED–PCC collaboration, including: defining techniques for establishment of an HIE connection for a patient, identification and implementation of standard document templates and terminologies, and development of tools for workflow integration such as a web-based dashboard for the PCC and the addition of notification functionality to existing emergency department information systems.

Mapping of Poison Center Data to HL7 C-CDA Consultation Note. We developed and maintained a computable mapping between the HL7 C-CDA schema and the Utah PCC database, an instance of toxiCall®. This mapping was tested and implemented in SNOWHITE, where it supports the function of creating and sending an HL7 C-CDA Consultation Note, and it is currently in use by the Utah PCC. [15]

Wireframing, User-Centered Design, and Formative Usability Assessments. We implemented a process of user-center design to design and develop SNOWHITE. The use of wireframing and early, iterative usability testing led us to an initial design and expedited eventual software development. Consultation and assessment by socio-technical informatics experts, including detailed

recommendations resulting from a formal heuristic usability evaluation, helped us create a second design that reflected later process and technical decisions. [16]

SNOWHITE Versions 1.0 and 2.0. We completed development of SNOWHITE versions 1.0, 1.1 and 2.0. SNOWHITE is a web-based application (Java-based REST web service) using Java script for the user interface and Java for managing and processing data. A MySQL database stores data related to auditing, login, and HL7 C-CDA documents. At the University of Utah, we are currently hosting the system in three environments, Development, Test, and Production. In order to successfully and securely send outgoing messages, the system depends upon health information exchange gateways. Figure 1 depicts the health information exchange process using SNOWHITE, showing the interaction with our regional health information exchange organization and indicating the University of Utah and UHIN gateways. Intermountain Healthcare's health information exchange architecture is not depicted. However, we are using the XDR pathway depicted in the diagram to exchange with Intermountain Healthcare. [20] [21]

The primary functions of SNOWHITE 2.0 include:

- View active PCC cases.
- Create *HL7 C-CDA Consultation Note*.
- Send *HL7 C-CDA Consultation Note*.
- View copies of previously sent *HL7 C-CDA Consultation Notes.*
- Receive and display information for three incoming (ED to PCC) *HL7 C-CDA* document types: *Referral Note*, *Progress Note*, and *Discharge Summary*.

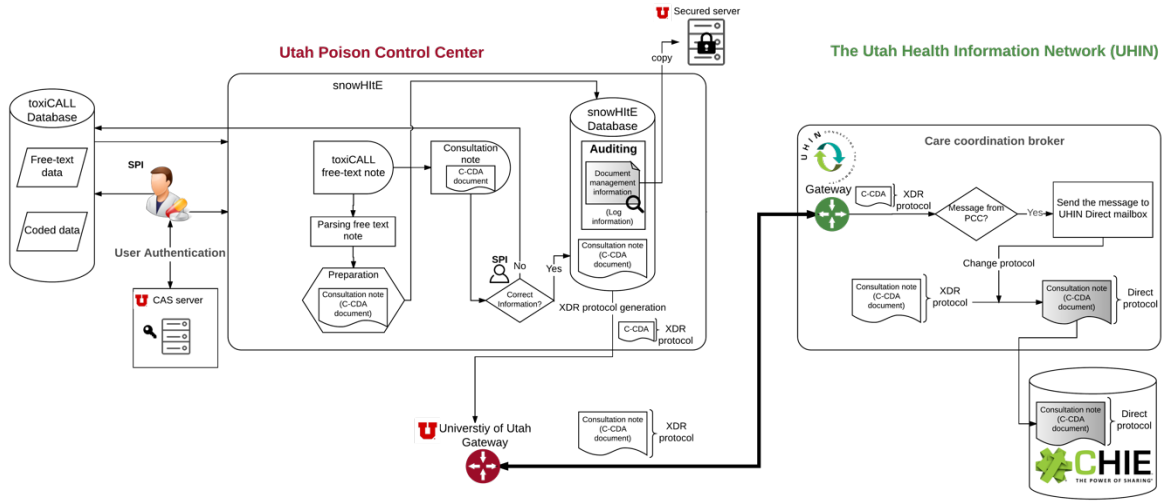

Figure 1 – Health Information Exchange Process Using SNOWHITE[21]

Implementation. We completed and implemented SNOWHITE v1.1 center-wide on March 29, 2017. SNOWHITE has been in operational use at UTAH PCC since that date. We implemented a subsequent version of SNOWHITE (2.0) with capabilities for receiving HL7 C-CDAs in 2018. UTAH PCC

began receiving inbound HL7 C-CDAs from Intermountain Healthcare on October 30, 2018. Between February, 17, 2015 and September 17, 2019, the UTAH PCC transmitted 4,549 outbound HL7 C-CDAs. Between October 30, 2018 and September 17, 2019, the UTAH PCC received 922,075 inbound HL7 C-CDAs from Intermountain Healthcare.

While we fully implemented bi-directional exchange of HL7 C-CDA *documents* between the Utah PCC and IHC EDs, and we fully implemented SNOWHITE in the *workflow and operations of the Utah PCC*, our Intermountain Healthcare collaborators are still working to complete technical integration into the ED tracking system and have not yet implemented the ED workflow in *ED operations*. This delay was largely due to a complete change in the electronic health record system used by Intermountain Healthcare during the grant. This event led to substantial and impactful delays throughout the course of the study, and presented unanticipated challenges to our research team, especially our Intermountain Healthcare collaborators, in the form of a differently designed electronic health record system with different functionality and health information exchange capabilities. We neared completion of pre-implementation testing for ED integration in summer of 2020, in effect, finalizing details in preparation for go-live. However, Intermountain's previously tested workflow for displaying Utah PCC HL7 C-CDA Consultation Notes as pre-arrivals in its ED tracking system began to fail. At the time of this report, the team at Intermountain Healthcare is attempting to determine the cause of the failure, which coincided with a recent iCentra software release. As the grant concluded, we remained in a supportive role, assisting the Intermountain Healthcare technical team with testing as they attempt to isolate and address the underlying issue.

Aim 3. Evaluate the effects of the model HIE process and informatics tools on workflow, communication, efficiency, and utilization. We will conduct a basic evaluation of the HIE supported collaboration process. We will determine user perspective through interviews and surveys, and will determine the effect on care delivery with objective measures of efficiency and utilization.

Completion of the primary analyses originally proposed in this study are dependent upon implementation of ED-PCC bidirectional health information exchange, a milestone that was extraordinarily challenged by a complete change in our partner health care organization's electronic health record system, and a milestone that we continue to pursue even after the completion of this study. However, we completed data collection in fall 2019 for a Utah PCC-based evaluation of SNOWHITE, and we've maximized our preparation for eventual post-implementation analysis by securing and preparing the pre-implementation data necessary for analyses. This will allow us to complete the analyses using minimal resources, when we are able to do so. In the meantime, we are proceeding with Utah PCC focused evaluation and continue to communicate and meet with our partners at Intermountain Healthcare.

Pre-implementation Analysis of ED Poisoning Data. We completed the query and data pull for pre-implementation ED data, and completed a related analysis describing the concordance of substance data.

Phone Time Analysis. We completed the analysis and preparation of pre-implementation phone time data, in support of post-implementation analysis.

User Evaluation of Software and Tools. We are currently analyzing data from November 2019 structured interviews with Utah PCC staff, and will conduct the planned surveys after ED side integration is accomplished and stable.

CONCLUSIONS

We successfully developed a process along with the software and informatics tools necessary for U.S. PCCs to participate in standards-based HIE. We implemented PCC health information exchange in 2017, with over 2.5 years in routine operations. Our multi-disciplinary, multi-organizational team (1) adapted the HL7 C-CDA consultation note standard for the PCC use case and created mappings from a PCC information system to the HL7 C-CDA consultation note, (2) designed a process and workflow modifications, and (3) developed an HIE dashboard that successfully facilitates poison center HIE. In ongoing work, we are progressing toward implementation of bi-directional, workflow integrated HIE using SNOWHITE.

SIGNIFICANCE AND IMPLICATIONS

Through this effort, we achieved first participation of a U.S. PCC in standards-based HIE. This critical achievement and associated findings paves the way for replicating and expanding standards-based HIE at other U.S. PCCs in other regions. PCC data and information can now be routed to multiple recipients and for different purposes, including individual patient care during poisoning emergencies such as overdose events. Our team designed the HIE architecture using standards that are required for EHR certification in the U.S., specifically HL7 C-CDA, XDR, and DIRECT, so that other regional HIE organizations, health care organizations, and PCCs can adapt our software and tools. In ongoing collaboration with IHC, we continue to work toward implementation of the developed and tested ED workflow integration, upon which the evaluation of workflow, efficiency and utilization outcomes will be based.

The PCC setting poses particular challenges for HIE because these centers do not bill for services and consequently, do not necessarily collect a robust set of patient identifiers. Additionally, they collect data in case-oriented vs. person-oriented information systems. Operational practices and information systems at PCCs must support the collection of patient identifiers to fully realize the potential of HIE, and we must work toward robust patient identity matching approaches for this use case. Currently, our design for ED-PCC HIE involves three layers of matching approaches, including automated matching based on standard algorithms, message routing based upon facility, and manual review linkage by ED clerks.

LIST OF PUBLICATIONS AND PRODUCTS

McDonald, A., Francis, L., Crouch, B.I. & Cummins, M.R. (In press, 2019). Legal Aspects of Information Sharing and Communication by Poison Centers in the United States. Clinical Toxicology. https://doi.org/10.1080/15563650.2019.1705478

Cummins, M., Iacob, E., Li, H. & Crouch, B.I. (2019). Concordance of Poison Control Data and ICD-10 Data for Substances of Abuse in ED Encounters (abstract). Proceedings of Addiction Health Services Research (AHSR) Conference. https://medicine.Utah.edu/internalmedicine/epidemiology/parcka/ahsr-conference/pdfs/ahsr-conf-booklet

Cummins MR, Ranade-Kharkar P, Johansen C, Bennett H, Gabriel S, Crouch BI, Del Fiol G, Hoffman M. Simple Workflow Changes Enable Effective Patient Identity Matching in Poison Control. Appl Clin Inform. 2018 Jul;9(3):553-557. doi:10.1055/s-0038-1667000. Epub 2018 Jul 25. PubMed PMID: 30045385; PubMed Central PMCID: PMC6059864.

Cummins, M.R., Del Fiol, G., Ranade, P., Iskander, A., & Khalifa, A. (2018) SNOWHITE v2.0 (Web-based dashboard for health information exchange by poison control centers)

SNOWHITE Development Team. (May, 2018). SNOWHITE: Health Information Exchange for Poisoning. High-Level Technical Design Documentation, Version 2.0

Khalifa A, Del Fiol G, Cummins MR. Public Health Data for Individual Patient Care: Mapping Poison Control Center Data to the C-CDA Consultation Note. AMIA Annu Symp Proc. 2017 Feb 10;2016:1850-1859. eCollection 2016. PubMed PMID: 28269944; PubMed Central PMCID: PMC5333325.

Tiase, V. L., Crouch, B. I., Bennett, H. K., Weng, C., Yang, R., Cummins, M. R. (2017). Descriptive analysis of communication patterns between a local poison control center and community emergency departments. Proceedings of the 2017 IEEE International Conference on Healthcare Informatics, 574. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8031217

Guo, J., Bennett, H., Crouch, B. I., Cummins, M. R. (2017). Reference website use patterns of poison control center specialists. Proceedings of the 2017 IEEE International Conference on Healthcare Informatics, 453. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8031191

Cummins, M.R., Del Fiol, G., Ranade, P., Iskander, A., Khalifa, A., & Narus, J. (2015-2017) SNOWHITE v1.0-1.1 (Web-based dashboard for health information exchange by poison control centers)

Nelson SD, Del Fiol G, Hanseler H, Crouch BI, Cummins MR. Software Prototyping: A Case Report of Refining User Requirements for a Health Information Exchange Dashboard. Appl Clin Inform. 2016 Jan 13;7(1):22-32. doi: 10.4338/ACI-2015-07-CR-0091. eCollection 2016. PubMed PMID: 27081404; PubMed Central PMCID: PMC4817332.

Del Fiol G, Crouch BI, Cummins MR. Data standards to support health information exchange between poison control centers and emergency departments. J Am Med Inform Assoc. 2015 May;22(3):519-28. doi: 10.1136/amiajnl-2014-003127. Epub 2014 Oct 23. PubMed PMID: 25342180.

Ranade-Kharkar, P., Mann, D.K., Bennett, H., Crouch, B., Del Fiol, G., Thornton, S.N., Cummins, M.R. (2016). Patient identity matching for health information exchange between poison control centers and emergency departments. Proceedings of the AMIA Annual Symposium 2016, 1562.

SNOWHITE Development Team. (October 2016). SNOWHITE: Health Information Exchange for Poisoning. High-Level Technical Design Documentation, Version 1.0

Hanseler, H., Nelson, S.D, Del Fiol, G., Crouch, B., & Cummins, M. (2016). A dashboard for health information exchange between poison control centers and emergency departments: the view from the poison control center. Proceedings of Utah Conference on Undergraduate Research.

Butcher, R., Martial, M.A., Gouripeddi, R., Cummins, M.R. (2015). Semantic interoperability of national poison center data. Proceedings of the IHTSDO SNOMED CT Expo. Montevideo, Uruguay.

Garg, N., Del Fiol, G., Crouch, B.I., Allen, T., Horowitz, B.Z., & Cummins, M.R. (2015). Modeling poison control center workflow with health information exchange. Proceedings of 2015 North American Conference on Clinical Toxicology, Clinical Toxicology, 53:7, 639-777. https://doi.org/10.3109/15563650.2015.1071025

Cummins, M.R., Crouch, B.I., Del Fiol, G., Narus, S., Thornton, S., & Allen, T. (2015). Advancing toward health information exchange for poison control centers. Proceedings of 2015 North American Conference on Clinical Toxicology, Clinical Toxicology, 53:7, 639-777. https://doi.org/10.3109/15563650.2015.1071025

Nelson, S.D, Del Fiol, G., Hanseler, H., Crouch, B., & Cummins, M. (2014). A dashboard for health information exchange between poison control centers and emergency departments: the view from the poison control center. 2014 Annual Meeting of the North American Congress of Clinical Toxicology (NACCT), Clinical Toxicology, 52:7, 682-818, DOI: 10.3109/15563650.2014.940163

REFERENCES

1. Fox D, Sillito J, Maurer F, editors. Agile Methods and User-Centered Design: How These Two Methodologies Are Being Successfully Integrated In Industry. Agile 2008 Conference; 2008; Toronto, Canada.
2. Gummin DD, Mowry JB, Spyker DA, Brooks DE, Osterthaler KM, Banner W. 2017 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 35th Annual Report. Clin Toxicol (Phila). 2018;56(12):1213-415. Epub 2018/12/24. doi: 10.1080/15563650.2018.1533727. PubMed PMID: 30576252.
3. Scholl L SP, Kariisa M, Wilson N, Baldwin G. Drug and Opioid-Involved Overdose Deaths — United States, 2013–2017. MMWR Morb Mortal Wkly Rep.67:1419-27. doi: http://dx.doi.org/10.15585/mmwr.mm675152e1.
4. Cummins MR, Crouch B, Gesteland P, Wyckoff A, Allen T, Muthukutty A, et al. Inefficiencies and vulnerabilities of telephone-based communication between U. S. poison control centers and emergency departments. Clin Toxicol (Phila). 2013;51(5):435-43. Epub 2013/05/24. doi: 10.3109/15563650.2013.801981. PubMed PMID: 23697459.
5. Spencer R, Coiera E, Logan P. Variation in communication loads on clinical staff in the emergency department. Ann Emerg Med. 2004;44(3):268-73. Epub 2004/08/28. doi: 10.1016/j.annemergmed.2004.04.006. PubMed PMID: 15332070.
6. Coiera EW, Jayasuriya RA, Hardy J, Bannan A, Thorpe ME. Communication loads on clinical staff in the emergency department. Med J Aust. 2002;176(9):415-8. Epub 2002/06/12. PubMed PMID: 12056992.
7. Brixey JJ, Robinson DJ, Turley JP, Zhang J. Initiators of interruption in workflow: the role of MDs and RNs. Stud Health Technol Inform. 2007;130:103-9. Epub 2007/10/06. PubMed PMID: 17917185.
8. Bernstein SL, Aronsky D, Duseja R, Epstein S, Handel D, Hwang U, et al. The effect of emergency department crowding on clinically oriented outcomes. Acad Emerg Med. 2009;16(1):1-10. PubMed PMID: 19007346.
9. Hoot NR, Aronsky D. Systematic review of emergency department crowding: causes, effects, and solutions. Ann Emerg Med. 2008;52(2):126-36. PubMed PMID: 18433933.
10. Patel VL, Zhang J, Yoskowitz NA, Green R, Sayan OR. Translational cognition for decision support in critical care environments: a review. Journal of biomedical informatics. 2008;41(3):413-31. PubMed PMID: 18343731.
11. Del Fiol G, Crouch BI, Cummins MR. Data standards to support health information exchange between poison control centers and emergency departments. J Am Med Inform Assoc. 2015;22(3):519-28. Epub 2014/10/25. doi: 10.1136/amiajnl-2014-003127. PubMed PMID: 25342180.
12. Garg NDF, G.; Crouch, B.I.; Allen, T.; Horowitz, B.Z.;Cummins, M.R. , editor Modeling poison control center workflow with health information exchange. North American Conference on Clinical Toxicology; 2015; San Francisco, CA.
13. Cummins MR, Ranade-Kharkar P, Johansen C, Bennett H, Gabriel S, Crouch BI, et al. Simple Workflow Changes Enable Effective Patient Identity Matching in Poison Control. Appl Clin Inform. 2018;9(3):553-7. Epub 2018/07/26. doi: 10.1055/s-0038-1667000. PubMed PMID: 30045385; PubMed Central PMCID: PMCPMC6059864.

14. Mcdonald AF, L; Crouch, BI; Cummins MR. Legal Aspects of Information Sharing and Communication by Poison Centers in the United States. Clinical Toxicology. In press. doi: https://doi.org/10.1080/15563650.2019.1705478
15. Khalifa A, Del Fiol G, Cummins MR. Public Health Data for Individual Patient Care: Mapping Poison Control Center Data to the C-CDA Consultation Note. AMIA Annu Symp Proc. 2016;2016:1850-9. Epub 2017/03/09. PubMed PMID: 28269944; PubMed Central PMCID: PMCPMC5333325.
16. Nelson SD, Del Fiol G, Hanseler H, Crouch BI, Cummins MR. Software Prototyping: A Case Report of Refining User Requirements for a Health Information Exchange Dashboard. Appl Clin Inform. 2016;7(1):22-32. Epub 2016/04/16. doi: 10.4338/ACI-2015-07-CR-0091. PubMed PMID: 27081404; PubMed Central PMCID: PMCPMC4817332.
17. Nelson SD, Del Fiol G, Hanseler H, Crouch B, Cummins M, editors. A dashboard for health information exchange between poison control centers and emergency departments: the view from the poison control center. North American Conference on Clinical Toxicology; 2014; New Orleans, LA.
18. Cummins MRDF, G.; Crouch, B.I.; Khalifa, A.; Iskander, A.; Mann, D.;Hoffman, M.; Thornton, S.; Allen, T.L.; Bennett, H. Enabling Health Information Exchange at a U.S. Poison Control Center. Unpublished manuscript, currently under review.
19. Ranade-Kharkar PM, DK ; Bennett, H ; Crouch, BI ; Del Fiol, G ; Thornton, SN ; Cummins, MR, editor Patient Identity Matching for Health Information Exchange between Poison Control Centers and Emergency Departments. American Medical Informatics Association; 2016; Chicago, Illinois.
20. Cummins MR; SNOWHITE Development Team. SNOWHITE: Health Information Exchange for Poisoning. High-Level Technical Design Documentation, Versions 1.0, 1.1. 2017.
21. Cummins MR; SNOWHITE Development Team. SNOWHITE: Health Information Exchange for Poisoning. High-Level Technical Design Documentation, Version 2.0. 2018.